Better Buildings by Design

We shape our buildings; thereafter they shape us.

Winston Churchill, Time*, September 12, 1960*

The "whole-building" approach to building design and construction results in buildings that use a fraction of the energy of similar buildings, without compromising comfort or aesthetics.

by Paul Torcellini

Robb Williamson

Zion National Park Visitor Center, Springdale, Utah

The National Park Service stayed true to its mission of protecting Zion National Park's natural beauty by creating a sustainable building that incorporates the area's natural features, renewable energy equipment and energy-efficient building concepts into an attractive design. The new Zion Canyon Visitor Center cost 30 percent less to build than a comparable conventional building, and is expected to use only 20 percent of the energy a similar conventional building would use. Some of the Visitor Center's innovative features include a Trombe wall, a photovoltaic system, daylighting, passive down-draft cooltowers and natural ventilation.

Americans spend most of their time inside buildings. We take for granted the shelter, protection, warmth, coolness, air and light that buildings provide, and rarely give a thought to the systems that deliver these services unless there's a power interruption or other problem.

In addition, few Americans understand the environmental consequences of maintaining indoor comfort levels. Today's buildings typically use mechanical equipment powered by electricity or fossil fuels for lighting, heating, cooling and maintaining air quality. Last year, buildings in the U.S. consumed more than one-third of the nation's energy and contributed 36 percent of the carbon dioxide (CO_2) emissions released into the atmosphere.

Fossil fuels burned to generate electricity and condition buildings emit other pollutants that cost citizens and insurance companies millions of dollars in health care costs each year. Mining and extraction of fossil fuels also have environmental impacts, and instability in pricing causes concern among both businesspeople and homeowners. Creating buildings that use less energy not only reduces and stabilizes costs, but also reduces environmental impact.

The good news is that we have the knowledge and technologies to reduce energy use in our homes and workplaces without compromising comfort and aesthetics. The bad news is that we are not taking full advantage of these advances—buildings are typically designed and operated without considering all the environmental impacts.

Whole-Building Design

But this is changing. For decades, researchers and innovative designers and builders have created buildings that use the environment as a resource rather than an obstacle to be overcome. Over the years, building professionals have steadily refined the equipment and design strategies used in these environmentally-responsive buildings. This evolutionary process and the resulting body of knowledge has led to the concept of "whole-building" design.

In the whole-building approach, designers create a computer model of a structure during the early stages of the design process. Using this model, together with improved communication among the various players in the design/build process, designers can integrate disparate building elements into the most energy-efficient, cost-effective and comfortable building possible.

The goal is to minimize the building's impact on the environment, and quite often the results are remarkable—dramatic savings in energy use without a substantial increase in design and construction costs. As a bonus, these buildings can improve the health, comfort and productivity of occupants in measurable ways. In commercial buildings, dollar savings from increases in productivity and reduced absenteeism can dwarf savings from reduced energy use.

Robb Williamson

Zion National Park Visitor Center Bookstore, Springdale, Utah

Daylighting at the new Visitor Center at Zion National Park reduces both lighting and cooling costs.

David Parsons

Otto Van Geet home, Idaho Springs, Colorado

Most of the energy needs of the Van Geet residence, located at 9200 feet above sea level in Clear Creek County, Colorado, are met by the sun—the home is not connected to the utility grid. Space heating comes from solar design with a Trombe wall for energy storage. An active (pumped) solar domestic hot water system provides hot water, and a 1000 watt photovoltaic system provides electricity. In addition, the house takes advantage of a number of energy efficiency construction techniques and energy-efficient appliances. For example, the walls are (high-mass) masonry with exterior insulation for maintaining even temperatures inside and the lighting consists primarily of compact fluorescent fixtures.

The DOE High-Performance Buildings Program

In 1998, the U.S. Department of Energy (DOE) began working with the commercial buildings industry to develop a 20-year plan for research and development on energy-efficient commercial buildings. More than 250 people from 150 building organizations worked together to create a technology roadmap report recommending strategies for making commercial buildings more energy efficient. The report is available on DOE's web site at: www. eren.doe.gov/buildings/commercial_roadmap/.

The overall goal of DOE's High-Performance Buildings Program is better buildings that save energy and provide a quality, comfortable environment for workers. The program is targeted toward the building community, especially building owners, engineers and architects. DOE, through the National Renewable Energy Laboratory, provides research-level assistance to create buildings with very aggressive energy goals such as the ones you see highlighted in this article.

We encourage building professionals to submit new commercial buildings to be a part of the High-Performance Building program. To participate, you must start very early in the design phase—before any other work is done—and must anticipate a 70 percent or more energy cost reduction.

If you are interested in participating in the High-Performance Building Program, contact Dru Crawley at the U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585 or high_performance@nrel.gov, www.eren.doe.gov/buildings/highperformance.

Jim Yost

BigHorn Home Improvement Center, Silverthorne, Colorado

This attractive, high-performance commercial building houses a retail complex located high in the Colorado Rocky Mountains. The developer of the complex was committed to whole-building design, creating one of the nation's first commercial buildings to integrate daylighting and natural ventilation cooling systems into a retail space. The building uses 62 percent less energy than a conventional retail center. Sustainable development was part of the business plan, and includes 9 kW of integrated photovoltaic panels.

Jim Yost

Natural daylighting helps reduce energy costs at the BigHorn Home Improvement Center retail complex in Silverthorne, Colorado. The daylighting features substantially reduce the electric lighting loads and minimize the cooling loads. Compact fluorescent fixtures supplement natural light when needed.

Success Stories

So, if these buildings are so great, why isn't everyone building them? Part of the answer is that building owners need to request and require this type of design, and the design teams need guidance during the process. Computer modeling is now available to provide guidance and to help minimize costly mistakes. But to move the marketplace, people want to see other people embracing the technologies.

To accelerate the adoption of whole-building strategies, the U.S. Department of Energy (DOE) is researching methods for substantially increasing the efficiency of buildings. This work includes developing better computer tools, working with design teams to improve the process and measuring results. DOE partners with owners, designers and builders interested in improving the energy performance and reducing the environmental impact of their buildings (see sidebars, page 41 and this page). To drive the point home, DOE and the National Renewable Energy Laboratory will present case studies of successful residential and commercial buildings in each issue of SOLAR TODAY for the next ten issues. For the purposes of these case studies, one measure of success is that the designers used a whole-building approach resulting in at least a 50 percent reduction in energy use compared with a similar conventional building.

In this issue, we kick off this series by highlighting some of the buildings we plan to feature. This sampling illustrates the diversity of design and function possible in buildings using the whole-building approach. These buildings also demonstrate how energy efficiency can work with renewable energy and new material technologies to successfully bridge the gap between the old way of thinking about building energy use and an energy-wise and environmentally healthy future. ✪

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Dwight Stone

Private residence, Penrose, Colorado

This low-energy solar home built by Tierra Concrete Homes of Pueblo, Colorado, uses about half of the energy of a typical new home built in the Pueblo area. The home features large, south-facing windows and is constructed with concrete walls. The high-mass concrete absorbs solar energy during the winter, which lowers heating bills. It also helps keep the temperature constant during the cooling season, with the result that the home does not require air conditioning.

The DOE Building America Program

The U.S. Department of Energy's Building America Program seeks to support systems engineering research to develop next generation housing. The Program works with the residential building industry to develop and implement innovative building processes and technologies. These innovations will have substantial impacts on builder and consumer costs.

If you are interested in participating in this effort, contact George James at the U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585 or george.james@hq.doe.gov. www.eren.doe.gov/buildings/building_america

Dwight Stone

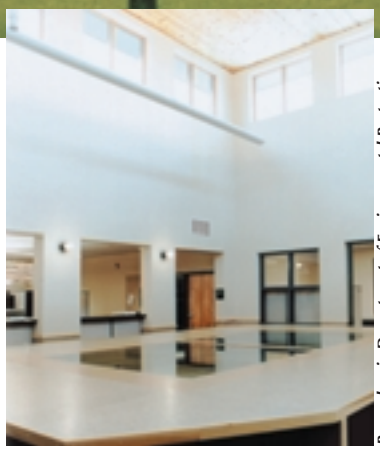
Private residence, Penrose, Colorado

The interior of this low-energy solar home built by Tierra Concrete Homes of Pueblo, Colorado, looks very much like any other home in the area. The only hint that this home uses the sun as a heating source is the large south-facing windows.

Pennsylvania Department of Environmental Protection

Cambria Office Building Ebensburg, Pennsylvania

The Pennsylvania Department of Environmental Protection constructed a 30,000 square foot district headquarters designed to minimize impacts on the environment from site selection and construction through building occupancy and operation. The building features extensive daylighting and 12-kW of photovoltaics, and a ground-source heat pump provides heating and cooling as well as domestic hot water. Many of the building materials are made from recycled materials and can be recycled for the "next generation" building.



Pennsylvania Department of Environmental Protection

Daylighting in the Cambria Office Building reduces energy use and costs associated with electric lighting.

Paul Torcellini

Emergency Services Building, Valmeyer, Illinois

Generous glazing in the Emergency Services Building in Valmeyer, Illinois, reduce the need for electric lights. High efficiency lights for use when needed and at night also keep lighting costs low.

Emergency Services Building, Valmeyer, Illinois

The Valmeyer Emergency Services Building is a 9000 square foot, passive solar, energy-efficient, city-owned building that houses Valmeyer's police station and volunteer fire department. The "whole-building" approach used in designing and building the structure requires architects, contractors, and developers to work together from the pre-design phase through commissioning the building. Features include daylighting for low-cost lighting, low-e glazing to maximize solar heating while minimizing heat transfer, high-efficiency fluorescent lighting and natural cooling. The building saves the city about $8000 every year in reduced energy costs compared to a similar conventional building.

Paul Torcellini